Is your patient actively seizing AND is the serum sodium < 125 mEq/L?

YES

Ask medication nurses to draw up hypertonic (3%) saline in 1mL/kg aliquots x 5 doses (no maximum dose)
Maintain airway, provide oxygen, and support ventilation as needed
Attach patient to monitor and pulse oximetry
Obtain IV/IO access – 2 sites desired (1 for medications/fluids, 1 for lab draws; do not draw labs through medication IV)
Obtain I-stat and serum renal profile

Ensure bedside RN rapidly IV pushes 1mL/kg of 3% saline, followed by standard NS flush
1 mL/kg of 3% saline, on average, raises the serum Na+ concentration by 1 mEq/L
Consider etiologies (see back page)

Seizure abates

Ensure adequate oxygenation
Manage airway as clinically indicated
Hold further 3% saline boluses and recheck I-stat to measure Na+ and PCO₂
Obtain urine for UNa+, Spec grav and UOsm
Re-check serum renal profile if has been >30 minutes since last one
Consult “The Pocket” and back of this page for further sodium management calculations and more information on etiologies and symptoms of hyponatremia
Discuss further management with neurology, endocrinology and/or nephrology
PICU consultation for admission because of high risk of seizure recurrence and need for q 1 hour labs and slow sodium correction over 24-48 hours

No

Do NOT use this algorithm

Still seizing 1 minute after flush

Still seizing 1 minute after flush

Still seizing 1 minute after flush

Still seizing 1 minute after flush

Still seizing 1 minute after flush

Ask medication nurses to draw up hypertonic (3%) saline in 1mL/kg aliquots x 5 more doses
I-stat to recheck serum Na+; send renal panel ONLY if not already done

Other considerations:
- If patient also hypoglycemic need to consider adrenal insufficiency, thus draw serum cortisol level and consider dose of hydrocortisone IV
- Consider use of anticonvulsant medications if clinical presentation does not seem fully consistent with hyponatremic seizure (see status epilepticus algorithm)
- Consider RSI to allow definitive airway and adequate ventilation
  - sedatives and paralytics limit evaluation of persistent seizure activity
- Strongly consider EEG if concern for subclinical status – must be arranged by neurology fellow
Symptoms of Hyponatremia (defined as serum Na < 135mEq/L):

- Anorexia, nausea, muscle cramps, lethargy, apathy, disorientation, agitation
- Neurologic symptoms usually do not occur until the serum sodium level has dropped to approximately 120-125 mEq/L and are related to how rapidly the sodium decreased
- Hyponatremia with decreased extra-cellular fluid (ECF) volume: irritability, apprehension, dizziness, postural hypotension, dry mucus membranes, cold and clammy skin, tremors, seizures
- Hyponatremia with normal or increased ECF volume: headache, lethargy, apathy, confusion, weakness, edema, weight gain, elevated blood pressure, muscle cramps, seizures

Causes of Hyponatremia (can be categorized into Hypovolemia, Euvolemia, Hypervolemia, Pseudo-hyponatremia):

- **Hypovolemia**: Decreased patient weight from baseline, low serum osmolarity (<280 mmol/L); decreased total body water (TBW) and Na; relatively greater decrease in Na
  - Renal Na losses: nephropathy, diuretics, RTA, adrenal insufficiency, cerebral salt wasting syndrome - UNa ↑, UVol ↑, UOsm↓ and Spec Grav↓
  - Cerebral salt wasting (CSW) is difficult to distinguish from SIADH – urine volume is low in CSW, not in SIADH
  - SIADH which has a very different treatment (fluid restriction)
  - Extrarenal Na losses: Diarrhea, fistulas, ostomies, vomiting, NG suction, skin losses (burns, wound drainage), 3rd spacing - UNa↓, UVol ↓, UOsm ↑ and Spec Grav↑; pancreatitis, peritonitis, small bowel obstruction, rhabdomyolysis, post-op
- **Euvolemia**: Normal TBW, near-normal total body Na; low serum osmolarity (<280 mmol/L); urine sodium < 10 mEq/L in water intoxication; urine sodium > 20 mEq/L in SIADH, hypothyroidism, Addison’s disease, or drugs
  - Post-op, narcotics, pain, emotional stress, SIADH syndrome; primary polydipsia
- **Hypervolemia**: Increase total body Na, relatively greater increase in TBW; low serum osmolarity (< 280 mmol/L); urine sodium < 10 mEq/L.
  - CHF, cirrhosis, acute/chronic renal failure, nephrotic syndrome
  - SIADH more commonly a euvolemic state, although management is often fluid restriction – discuss with nephrology prior to fluid management
- **Hyperglycemia, hyperlipidemia**, and **hyperproteiinemia** may cause a *pseudo-hyponatremia*
  - Hyperglycemia – Na decreases by 1.6 for each 100 mg/dl increase in glucose over 100 mg/dL; Hyperproteinemia – Na decreases by 0.002 x lipid mg/dL; Hyperproteiinemia – Na decreases by 0.25 x [protein g/dl – 8]
  - Serum osmolality will be decreased except in cases of pseudo-hyponatremia, azotemia, or toxins that increase osmolality (example: ethanol).

Management of hyponatremia: The goal of therapy is to get the patient out of immediate danger (return the sodium level to 120 mEq/L or greater) and then gradually return the serum sodium to a normal level and restore normal ECF volume

- When hyponatremia is symptomatic and acute (< 24 hours in duration), the serum sodium may be raised safely to 120-125 mEq/L in 24 hours or less.
- In patients with symptomatic chronic hyponatremia, or hyponatremia of unknown duration, the serum sodium should be raised slowly (0.5 mEq/L/hr) to about 120 mEq/L in order to avoid CNS complications (pontine myelinolysis, seizures) and/or pulmonary edema. The total increase in these patients should not exceed 10-12 mEq/L in 24 hours or 20-25 mEq/L over 48 hours. Thereafter, the hypertonic saline is stopped, and the serum sodium is allowed to rise more slowly. In all cases, the serum sodium should be corrected only halfway to normal in the initial 24 hours (120-125 mEq/L) to prevent the complications listed above.
- Clinical indicators and treatment depend on the cause of hyponatremia and whether or not it is associated with a normal, decreased or increased ECF volume. Labs to order include I-Stat, renal panel, urine Na, plasma osmolality, & urine osmolality.

**Example for hypovolemic hyponatremia:**

- Calculate sodium deficit:
  - TBW x (Desired sodium - Actual sodium), where desired sodium is 120 mEq/L = total sodium needed in mEq
  - TBW (total body water) = weight in kg x % water
  - % Water = 0.6 in children, 0.6 in adult males, 0.5 in adult females
- Calculate the rate of normal saline (NS) needed to increase sodium level by 0.5 mEq/L/hr:
  - TBW x 0.5 = rate in mEq/hr
  - [(rate in mEq/hr)/154 mEq/L] x 1000mL/L = infusion rate for NS saline in mL/hr
- Calculate length of infusion in hours:
  - Total sodium needed in mEq divided by rate in mEq/L = hours of infusion
- Example: 15kg patient with serum Na level 108
  - 0.6 x 15 x (120-108) = 108 mEq needed
  - 0.6 x 15 x 0.5 = 4.5 mEq/hr
  - [4.5/154] x 1000 = 29.2 mL/hr
  - 108/4.5 = 24 hours
  - Thus, run NS saline at 29 mL/hr for 24 hours to provide 108 mEq of Na, thus raising serum sodium from 108 to 120 mEq/L

Available fluid concentrations:

- 3% saline has 513 mEq/L of sodium
- Normal saline has 154 mEq/L of sodium
- Ringer’s Lactate has 130 mEq/L of sodium